

Appl No.: 10/683,603
Reply to Office Action of April 25, 2006

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REMARKS/ARGUMENTS

Favorable consideration of this application is respectfully requested. Applicant has amended the specification by updating the status of the parent application, added a new paragraph to the specification to provide consistent use of terminology, and revised the current abstract to more accurately describe the invention, limiting the description to 150 words or less, and correcting grammatical errors. Claims 15 – 19 are withdrawn because of a restriction requirement. Claim 20 was previously canceled. Claims 21-26 are now pending. No new matter has been entered. Favorable reconsideration is earnestly solicited in view of the following remarks.

With regard to the restriction requirement discussed with Applicant's attorney on March 23, 2006, Applicant has elected to prosecute the invention of Group II, claims 21-26, with traverse. This election is made with traverse for the following reasons.

First, the suggested inventions listed in Groups I and II could be searchable within the same art unit and at the very least searchable within the same Group 1745. Group I and II inventions, have the same inventors, encompass the same apparatus with the added feature that the Group II invention is integrated with a fuel cell for the generation of electricity. If these inventions are classified in the same Group, it would not create an undue burden on one Examiner to complete searches and an examination on the merits for each of these two apparatus inventions, at one time.

Thus, any restriction requirement could have the effect of having different examiners working on the other species. Further, multiple examinations on these species would be repetitive and excessive. Finally, separate prosecution could create an unnecessary financial burden for the Applicants. For these reasons, Applicants request reconsideration and withdrawal of the restriction requirement. Applicants find the restriction requirement improper and Applicants

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respectfully request the removal of the restriction requirement. Further, Applicants reserve the right to file a divisional application for the non-elected invention in Group I, Claims 15 – 19.

Referring now to each of the Examiner's objections beginning on page 4, paragraph 10, of the Office Action of April 25, 2006, Applicants address each objection in sequence below.

In paragraph 10, the Examiner states that the drawings are objected to as failing to comply with 37 CFR 1.84(p)(4) because reference character "1" has been used to designate reactors having different names. By amending the specification after the paragraph ending on line 27 of page 5, Applicants have provided clarification of terms used when referring to character "1." No new matter is added with this clarification and Applicants find that the drawings do not need amendment nor replacement because there is only one reactor in Applicant's invention, and it is appropriately designated with the character "1." Accordingly, Applicants respectfully request the withdrawal of the Examiner's objection to the drawings as failing to comply with 37 CFR 1.84(p)(4). There were no corrections made to the drawings, thus no replacement sheets are submitted.

In reply to the Examiner's objection (paragraph 11) to the language and format of the Abstract of the disclosure, Applicants have reworded the abstract to less than 150 words and eliminated the preamble, "This invention relates to." Support for the revised Abstract is found in the original Abstract, in the specification at page 5, lines 13-14; page 7; lines 5-16, 21-23 and the sentence beginning in line 30 of page 7 and ending on page 8, line 2. No new matter is added by the revision; accordingly, Applicants respectfully request the withdrawal of Examiner's objections to the Abstract.

Applicants acknowledge the Examiner's comment in paragraph 12, that the preliminary amendment of 10/10/03 does not introduce new matter into the disclosure.

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In paragraph 13 of the Office Action of April 25, 2006, the Examiner objects to the informalities related to including the current status of the parent application in the specification. Applicants have amended the specification at page 1, line 4 including the status of the parent application, accordingly, it is respectfully requested that this objection be withdrawn.

In paragraph 14, the Examiner objects to claim 24 because of a typographical error that left a blank space and separated the last terms of line 2; this error has been corrected. Applicants respectfully request the withdrawal of the objection.

Referring now to the Examiner's rejection of Claims 21-26 in paragraphs 14 – 28 of the Office Action of April 25, 2006, Applicants have amended the claims to specifically claim the inventive features and thereby distinguish the present invention from each of the references cited by the Examiner. No reference cited teaches or suggests the use of apparatus for the continuous reactivation of a carbon catalyst, in a manner disclosed by Applicants, that improves the activity and stability of the catalyst during thermocatalytic decomposition of hydrocarbons.

First, a succinct statement of Applicants' invention is: An apparatus (consisting of one reactor, one cyclone, one grinder, a heater, heat exchangers and a gas separation unit that is integrated with a fuel cell) for generating electricity; the apparatus first produces pure hydrogen and carbon via continuous thermocatalytic decomposition of hydrocarbons employing both internal and external activation of the carbon catalyst, then transports pure hydrogen to the anode of the fuel cell to generate electricity. [*Underlining added to identify the inventive concepts.*]

Claim 21 is now amended to describe the complete function of the apparatus in the preamble. Support for this amendment is found in original claim 15; page 5, lines 5 – 8. Claim 21 is further amended to include the step of purging moisture and air from the moving bed of carbon particulates which is important for the CO₂-free production of hydrogen and carbon. Support for

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this amendment is found in Example 1, page 9, lines 17-19; Example 4, page 10, lines 22-23; Example 7, page 12, lines 3-4.

In Claim 21 the archaic term "said" is replaced with the term "the." This amendment adds no new matter; rather it updates the language of the claims. Another amendment to Claim 21 is in step (d) where hydrogen-containing gas is separated into pure hydrogen and a hydrogen-depleted gas stream. Support for this amendment is found in original claim 1 and page 5, lines 10-13.

Step (e) of claim 21 is amended to identify the inventive step of recycling of the hydrogen-depleted gas to accomplish internal activation of the carbon catalyst. Support for this amendment is found on page 7, lines 8-10; page 5, lines 11-13 and the original Abstract.

Step (f) of claim 21 is amended to show that carbon particles are recovered from the reactor prior to step (g) the disintegration of the carbon particles in a grinder. Support for this amendment is found on page 6, lines 14-15; page 7, lines 10-12.

Step (g) of claim 21 is amended to restate original step (d) with clarity. Support for this amendment is found in original Claim 21, step (d); page 7, lines 10-16.

Step (h) of claim 21 is amended to identify another inventive step of heating carbon particles to provide externally activated catalyst for the reactor. Support for the amendment to step (h) is found on page 7, lines 10 - 16; page 16, lines 12-15.

Referring now to Claim Rejections under 35 USC §112, second paragraph, Applicants make the following amendments:

Claim 22 is amended to clarify the fact that the thermocatalytic reactor has a moving bed of carbon particulates as explained in the specification at page 5, lines 8-9 and 28-30; page 7, lines 10-12; page 12, line 5. Claim 22 is rejected, in paragraph 17 of the Office Action of April 25, 2006, as being indefinite for failing to particularly point out and distinctly claim applicants'

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invention because the Examiner finds an insufficient antecedent basis for the limitation "the moving bed reactor." When the amendment to Claim 22 is entered, Applicants respectfully request the withdrawal of the rejection of Claim 22 under 35 USC §112, second paragraph.

Claim 24 is amended to replace "the means of recovering pure hydrogen" to read "*means for*" to correspond to the language used in the independent claim on which Claim 24 depends. Thus, Applicants respectfully request that the Examiner's rejection of Claim 24 under 35 USC §112, second paragraph, in paragraph 18 of the Office Action of April 25, 2006 be withdrawn.

Claim 25 is amended to replace "the means of disintegration" to read "*means for*" to correspond to the language used in the independent claim on which Claim 25 depends. Accordingly, Applicants respectfully request that the Examiner's rejection of Claim 25 under 35 USC §112, second paragraph, in paragraph 19 of the Office Action of April 25, 2006 be withdrawn.

Claim 26 is amended to claim that a specific fuel cell used in the generation of electricity is a polymer electrolyte membrane fuel cell. Support for this amendment is found in the specification on page 5, lines 3-4 and 13-14; page 8, lines 16-23; Figure 2 and original claim 26.

The Examiner rejected original claim 26 under 35 USC §112, second paragraph, in paragraph 20 of the Office Action of April 25, 2006 because "the means of transporting and generating electricity" did not have an antecedent basis in Claim 21 on which it depends; there was also no recitation of "a means for generating electricity" in Claim 21. Applicants' amendments to Claim 26 have addressed the grammatical construction of the claim and altered its meaning to coincide with the teaching in the specification; thus, it is respectfully requested that the rejection be withdrawn.

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No new matter has been added by the amendments to Claims 21, 22, 24 - 26. Applicants' invention is now set forth in claims that are clearly distinguishable from any references cited by the Examiner, including the Double Patenting rejection discussed below.

Double Patenting Rejection: In paragraph 22 of the Office Action of April 25, 2006, the Examiner rejects Claims 21, 23-24 and 26 on the ground of non-statutory obviousness-type double patenting as being unpatentable over claims in U.S. Patent No. 6,653,005 to Muradov, one of the inventors of the present invention. Muradov '005 claims an integrated hydrogen generator-fuel cell apparatus that uses a carbon catalyst. What was not known nor disclosed by the Muradov '005 reference is the discovery in the present invention that by-products of the thermocatalytic decomposition of hydrocarbons could be used for both internal and external activation of the carbon catalyst which significantly improves the activity and stability of carbon catalysts during the thermocatalytic process. Applicants now claim this discovery and respectfully disagree with the Examiner's argument that "*the claims of US Patent '005 fully encompasses or anticipates the claimed subject matter of the application claims.*"

Where is there any suggestion that a portion of hydrogen-depleted gas be recycled to the reactor to sustain high catalytic activity of the carbon catalyst in-situ? Where is there any suggestion that the carbon particles from the reactor be ground in a grinder and heated to provide external activation of catalyst for the reactor? Applicant has amended the claims to clearly identify the invention herein that sustains high catalytic activity; this invention was not even contemplated by the Muradov '005 reference. Accordingly, Applicants respectfully request that the Double Patenting rejection be withdrawn.

However, to expedite the prosecution of this application, Applicants have filed a terminal disclaimer to avoid double patenting of the invention in Muradov '005. However, if, on

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reconsideration, the Examiner withdraws the double patenting rejection, this terminal disclaimer can be withdrawn.

Claim Rejections under 35 USC §102:

Claims 21-22 are rejected under 35 U.S.C. 102(b) as being anticipated by Gür et al. in U.S. Pat. 5,376,469 (paragraph 24 of the Office Action of April 25, 2006). As to claim 21, the Examiner argues that Gür et al. disclose direct electrochemical conversion of carbon to electrical energy in a high temperature fuel cell. Electrical power is generated from the fuel cell by placing carbon fuel in a temperature zone of the fuel compartment. The apparatus used by Gür et al. is completely different from the apparatus used by Applicants. Gür et al. do NOT use a reactor, cyclone, heater, grinder and products of the thermocatalytic decomposition of hydrocarbons for continuous reactivation of the catalysts internally and externally. Gür et al. use carbon as a fuel, whereas Applicants use hydrocarbon as a fuel and produce carbon as a product.

Further distinctions between Gür et al. and Applicants invention are the reactors used. The Examiner asserts that the fuel compartment 20 of Gür et al. represents the thermocatalytic reactor; this is not correct. The main reaction occurring in the fuel compartment 20 is non-catalytic combustion or oxidation of carbon. In contrast, Applicants produce carbon and hydrogen via carbon-catalyzed decomposition of hydrocarbons.

A further distinction is that in Gür et al., hydrogen is not produced in the fuel compartment, but rather pre-exists as an impurity in the carbon feedstock. For Applicants, hydrogen is produced along with carbon as a main reaction product.

Gür et al. is applicable to only high-temperature solid oxide fuel cells (due to the nature of the solid electrolyte membrane), whereas, Applicants' invention is applicable to any type of fuel cell, including low temperature fuel cells, such as polymer electrolyte membrane (PEM)

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Finally, Gür et al.'s device produces only one useful commodity: electricity, in contrast, Applicants' apparatus/ process produces two useful commodities: electricity and carbon.

As to claim 22, the Examiner argues that Gür et al. discuss the use of a fluidized bed reactor; thus the present claims are anticipated. That is tantamount to saying that anyone who uses a fluidized bed reactor anticipates Applicants' invention. The Gür et al. patent discloses a very different invention than Applicants and with the amendments to the claims, Applicants have clearly distinguished the present invention from Gür et al. Applicants respectfully request the withdrawal of the rejections of Claims 21 and 22 under 35 U.S.C. 102(b) as being anticipated by Gür et al. in U.S. Pat. 5,376,469.

In paragraph 26 of the Office Action of April 25, 2006, inventorship and patentability of claims under 35 U.S.C. 103(a) are being considered with regard to subject matter of the various claims being commonly owned at the time any inventions covered therein were made. Applicants affirm that the subject matter claimed and each claim herein has the same inventorship and is commonly owned.

In paragraph 27 of the Office Action of April 25, 2006, Claims 21-26 are rejected under 35 U.S.C. 103 (a) as being unpatentable over Krebs (U.S. Pat. 2,805,177) in view of DuBosc (U.S. Pat. 6,436,562).

As to claim 21, the Examiner argues that Krebs discloses the production of hydrogen and coke by cracking of gaseous hydrocarbon over coke particles by the addition of heavy hydrocarbon oils. Although Applicants have amended claims that focus on the apparatus to continuously sustain a high level of catalytic activity internally and externally, thus distinguishing Applicants invention from all cited references, Applicants choose to point out some fundamental differences between the Krebs' patent and Applicants' invention.

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Krebs' patent describes gaseous hydrocarbon being thermally decomposed (cracked) at about 1150C over coke particles produced by cracking of residual oil. Thus, the process requires an additional feedstock (heavy hydrocarbon oil or residuum feed) for the process to function (in addition to the gaseous hydrocarbon feed). In contrast, Applicants' process is self-sustained and does not require any additional feed; it uses carbon particles produced from gaseous hydrocarbon feedstock.

Further, Applicants' process allows for continuous activation of carbon particles by recycling hydrogen-depleted gas to the reactor and by grinding carbon particles and heating the particles as an external source of activated catalyst. The apparatus and process for the continuous activation of catalysts is not suggested or taught by Krebs.

Finally Krebs does not purge the catalyst bed of moisture and air so that undesirable contaminants are formed, thus Krebs would have a much higher amount of CO and CO₂ emissions than Applicants.

Examiner's further arguments are: "As to claim 22, Krebs uses a fluidized bed reactor"; the use of a fluidized bed reactor is not a critical feature of Applicants' invention. As to claim 23, Krebs uses carbon black; carbon black is a product of the cracking process (Col 1, lines 45-48), whereas, in Applicant's invention, carbon black is a catalyst for the process.

As to claim 21 and 24, the Examiner argues that solid/vapor separating devices 5 and 12 separates the hydrogen product from the remaining residual gas, *thus, they are hydrogen separation units*. This is an incorrect assertion. The solid/vapor separating devices 5 and 12 in the Krebs' patent functionally operate as cyclones (not as gas separation devices). Thus, cyclone 5 separates gaseous products from hot coke particles (Col 2, lines 37-39), not hydrogen from the

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remaining residual gas as the Examiner incorrectly states. Cyclone 12 separates flue gas from hot coke particles (Col 2, lines 48-50).

As to claim 25, the Examiner argues that for Krebs, hopper 7 represents the grinder. Applicants disagree. The role of the hopper 7 in Krebs' patent is to store carbon particles before they enter a standpipe 8 and a carbon product line 14. Thus, no change in the size of carbon particles occurs in the hopper 7. The role of the grinder in Applicants invention is to reduce the size of carbon particles formed in the process via mechanical grinding in order to maintain the constant inventory of carbon particles with the required dimensions to produce an adequate fluidization in the fluidized bed reactor (FBR).

The Examiner acknowledges that Krebs does not disclose the integration of the apparatus for the production of hydrogen and carbon with a fuel cell for generating electricity, thus the DuBose reference is cited for its teachings about the utility of fuel cells incorporating reformer technology to crack hydrocarbons to obtain hydrogen to feed the fuel cell (Col 1, lines 40-48). Thus, the Examiner rejects Claims 21-26 with the argument that "... it would have been readily apparent to a person possessing a level of ordinary skill in the art ... to integrate the specific fuel cell for generating electricity of DuBose with the hydrogen production apparatus of Krebs. . ."

The notion of integrating or combining different hydrocarbon reformers, including cracker-reformers, with different types of fuel cells has been known for decades -- even before the Krebs' patent. For example, see Callahan, Proc. 26th Power Sources Symposium, Red Bank, N.J. 181, 1974. Applicants have disclosed and are claiming the sustainable production of electricity and carbon from a variety of hydrocarbon fuels with minimal CO₂ emissions; the inventive concepts include producing pure hydrogen and clean carbon with an apparatus to recycle hydrogen-depleted gas to the reactor for internal catalyst activation and grinding and heating carbon particles that are

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returned to the reactor for external catalyst activation. Applicants' invention provides significant improvements over the deficiencies of the prior art.

For example, the combination of the hydrogen production process of the Krebs' invention with a fuel cell of Du Bose would require an additional residual oil feed and operation at temperatures above 1400C which would necessitate specialty construction materials negatively affecting the process economics.

Moreover, the Krebs' process does not include a hydrogen purification system, and as a result, hydrogen gas will exit the system "together with other vaporous products" (Col 2, line 34); such impurities are potentially detrimental for the operation of the fuel cell. Finally, due to a heavy hydrocarbon feedstock, i.e., one with high carbon content, the Krebs' process would produce significant quantities of CO₂ emission. In contrast, Applicants' invention provides an economic solution to catalyst activation and regeneration, purifies hydrogen gas to meet the fuel purity requirements of the fuel cell; operates at lower temperatures, purges the reactor bed of air and moisture and, as a result, produces less CO₂ emission.

In paragraph 28 of the Office Action of April 25, 2006, Claims 21-25 are rejected under 35 U.S.C. 103 (a) as being unpatentable over Krebs (U.S. Pat. 2,805,177) in view of Poirier's publication "*Catalytic Decomposition of Natural Gas to Hydrogen for Fuel Cell Applications.*"

As to claim 21, the Examiner argues that Krebs discloses the production of hydrogen and coke by cracking of gaseous hydrocarbon over coke particles by the addition of heavy hydrocarbon oils. As to claim 22, the Examiner argues that Krebs uses a fluidized bed reactor. As to Claim 23, the Examiner asserts that Krebs uses carbon black. As to Claim 24, Krebs uses solid/vapor separating devices; "*Thus, they are hydrogen separation units.*" Further, the

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Examiner argues that as to claim 25, "Ilopper 7 represents the grinder." These arguments and assertions are the same as those presented earlier with regard to Claims 21-26 as rejected under 35 U.S.C. 103 (a) as being unpatentable over Krebs (U.S. Pat. 2,805,177) in view of DuBose (U.S. Pat. 6,436,562).

The Examiner views the Poirier publication as teaching catalytic decomposition of natural gas to produce hydrogen for fuel cell applications and concludes, *"Therefore, the Poirier's publication at once envisages the combined use of the catalytic decomposition reactor with a fuel cell, thereby for generation of energy."*

The above arguments for the withdrawal of the rejection of Applicants' claims because of the teachings of Krebs in view of Du Bose hold true for the rejection of Applicants' claims because of the teachings of Krebs in view of Poirier. The integration of the Krebs' hydrogen production process with the specific fuel cell disclosed in Poirier's publication would have the same deficiencies as those of the integrated unit related to Krebs in view of DuBose, since in both cases the preferred type of fuel cell is the PEM fuel cell. It should be noted that the Applicants' patent application also improves on the deficiencies of the integrated system comprising the Poirier catalytic reactor and the Poirier specific fuel cell (i.e., PEM). Specifically, the Poirier catalytic reactor (to be exact, the tandem of two parallel reactors) operates in a semi-continuous cyclic decomposition-regeneration mode, which significantly complicates the system and contributes to the contamination of hydrogen with carbon oxides.

Further, in the Poirier's reactor, an all-carbon product is combusted during catalyst regeneration cycle, which results in low overall energy efficiency (about 50%) and production of significant amount of CO₂ emission. In contrast, Applicants use the recycling of hydrogen-

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depleted gas to maintain a high level of catalyst activation and grind and heat carbon particles as an added means for catalyst activation.

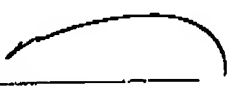
In addition, Poirier's reactor utilizes expensive Ni-based catalyst, which is prone to deactivation by sulfurous impurities in the feedstock. In contrast, Applicants do not use this expensive Ni-based catalyst.

Finally, the Poirier system produces only one useful commodity: electricity. In contrast, Applicants' process/apparatus uses inexpensive carbon catalyst and operates in a continuous mode; it produces two useful commodities, electricity and carbon, and produces an insignificant amount of CO₂ emissions because only a small portion of carbon is combusted to provide the process heat input.

In view of the above arguments, Applicants respectfully request the withdrawal of the rejection of Claims 21-25 under 35 U.S.C. 103 (a) as being unpatentable over Krcbs (U.S. Pat. 2,805,177) in view of Poirier's publication "*Catalytic Decomposition of Natural Gas to Hydrogen for Fuel Cell Applications.*"

The application and claims are believed to be in condition for allowance in their amended form; allowance of Claims 21-26 is respectfully requested. If the Examiner believes that an interview would be helpful, the Examiner is requested to contact the attorney at the below listed number.

Respectfully submitted,



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